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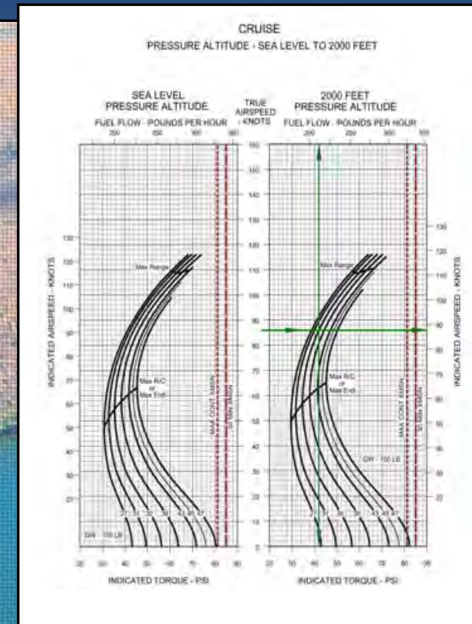

Software Test Appliance Techniques (STAT) for Software Systems

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14. ABSTRACT

The dependencies in complex software systems are stretching industry software test capabilities such that schedules and budgets are constantly being compromised at the risk of producing software with more defects and reliability issues. STAT technologies are being integrating within our production code to facilitate improved testability and reliability. Modeled from techniques utilized in hardware systems commonly titled Built-in Test (BIT), STAT is used to develop applications that support testability without sched le compromising schedule and budget. The authors have found that STAT supports the development and deployment of robust software applications. ? Non-intrusive test techniques ? Improved reliability ? Supports test automation ? Improves integration success

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Abstract

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- Non-intrusive test techniques
- Improved reliability
- Supports test automation
- Improves integration success

Contents

The purpose of this briefing is to provide an understanding of what a Software Test Appliance is and how it can be applied to building robust and reliable Software Applications.

- Background
- Example Software Systems
- Non-intrusive test techniques
- Improved reliability
- Supports test automation
- Improves integration success

Background

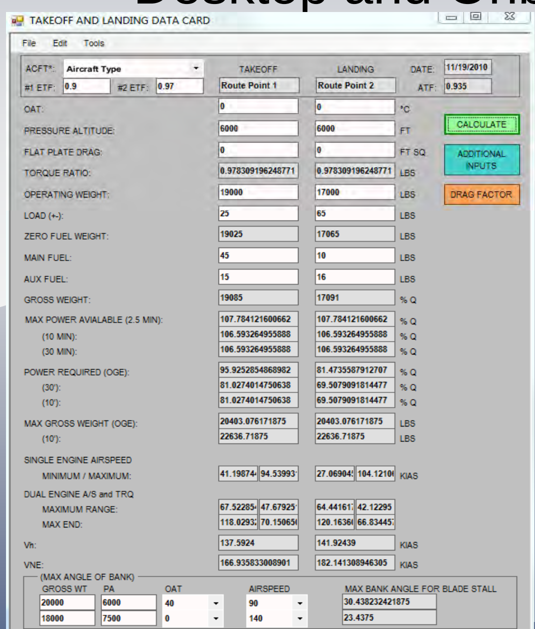
- 25+ years in Industry
- Emphasis on Software Engineering
- Embedded systems for Medical applications
- Embedded systems for Aircraft avionics.
- Numerical models for University Research
- High speed measurement tools

Sample Software Systems

- Mission Planning Software
- Flight Performance Planning Models
- Embedded Flight Performance Models for Mission Execution

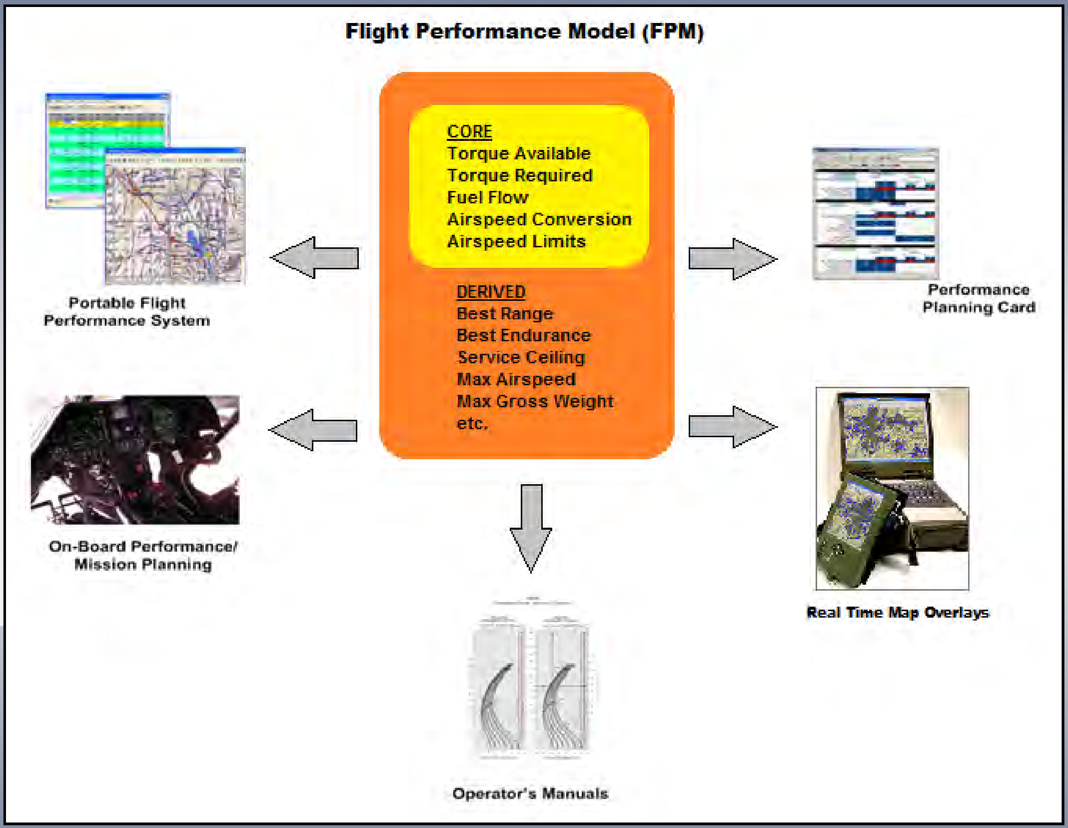
Mission Planning and Performance Software

- Flight Performance Models - Digital models of aircraft performance flight capabilities and limitations
- Developed by combining flight-test and engineering data with standard mathematical models (equations) of aircraft performance
- Rotary Aircraft - Performance Planning Cards (PPC)
- Fixed Wing Aircraft – Take Off and Landing Data (TOLD)
- Desktop and Onboard Embedded Applications



- Platforms
  - Apache
  - Blackhawk
  - Chinook
  - Kiowa warrior
  - JCA
  - Sherpa
  - Citation

Flight Performance Models - Desktop



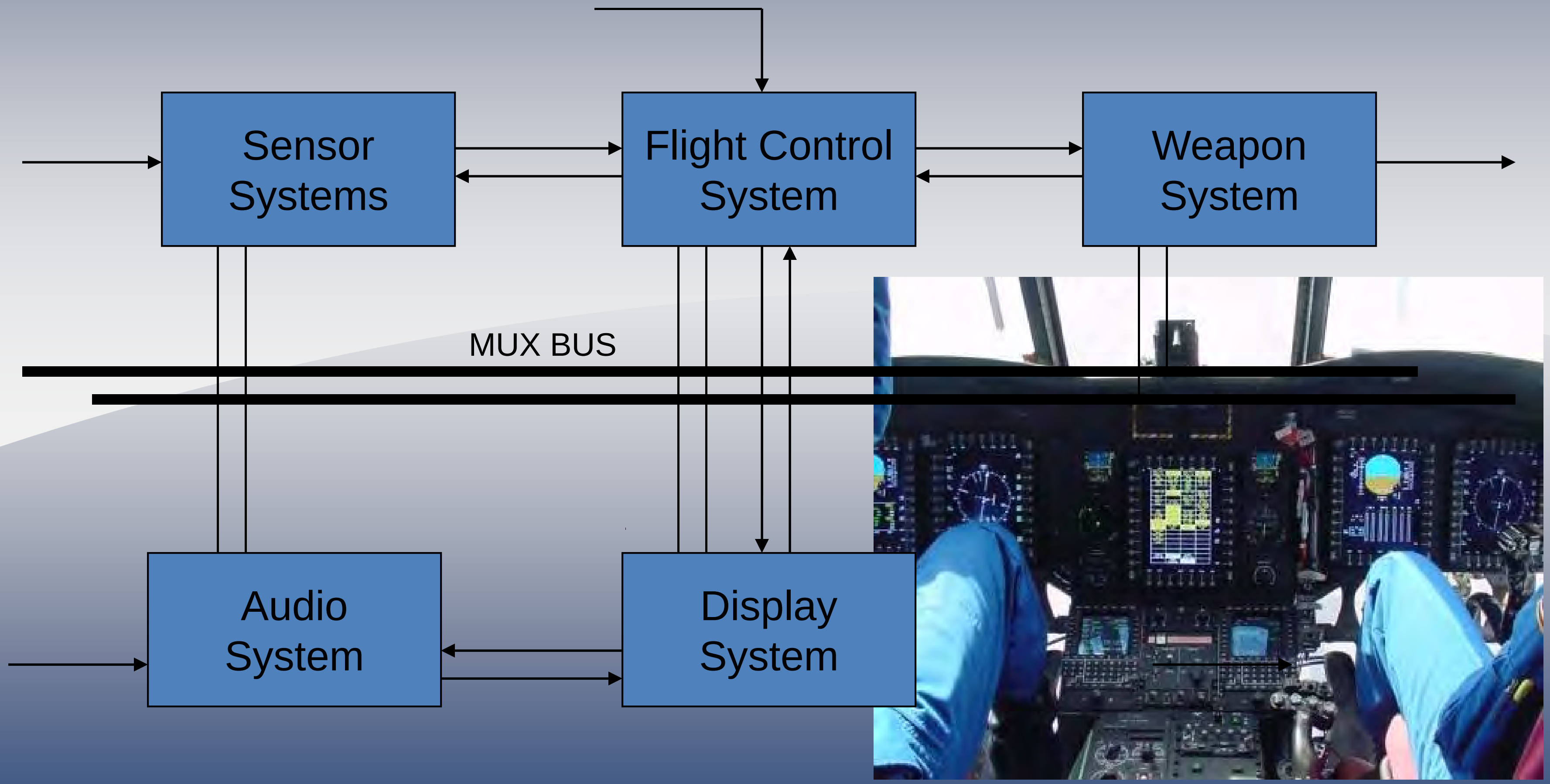
- Flight Performance Model integrated with desktop applications
  - Integrated Performance and Aircraft Configuration (IPAC)
  - Portable Flight Planning Software (PFPS)
  - Aviation/Joint Mission Planning System (AMPS/JMPS)
  - Falconview
  - Operators Manual Charts

Flight Performance Models - Embedded

- Embedded Flight Performance Models (EFPM) are being inserted into fixed wing and rotary wing cockpits
- Enables onboard flight performance and mission planning
- Accurate and consistent with desktop applications
- Very fast execution, very small memory requirements
- Efficient numerical methods to create faster EFPMs
  - Non-dimensional data
  - Higher-order interpolation
  - Pre-processing
- Currently have EFPM onboard
  - OH-58D
  - UH-60M
  - CH-47F
  - MH-47G
  - MH-60K/L/M

Systems within a System

Today's systems are becoming systems of Software Systems



Software Systems Components

- Standardized interfaces
- Abstracted capabilities
- Functions
  - Producer
  - Consumer
  - Mediators
- Coupling Complexity
  - Data
  - Control

Data Coupling

- Data coupling - The dependence of a software component on data not exclusively under the control of that software component. (DO-178B)
  - Define the behavior for the input domain
  - Bounds check the component
    - Outside the bounds
    - At the bounds
    - The entire domain

Control Coupling

- Control coupling - The manner or degree by which one software component influences the execution of another software component. (DO-178B)
  - Requirements must fully specify switches
  - Test must exercise each switch
  - Reduce control coupling, reduce test cases

Goals of Testing

- Prevent bugs in software and hardware before deployment.
- Discover symptoms of bugs <u>*before*</u> they affect safety or functionality of systems.
- Provide diagnostic information on detected bugs.

Goals of Software Test Appliance

Goals of testing listed above *plus:*

- Non-intrusive verification of proper functionality of systems for operational system status.
- Non-intrusive data collection to support the verification of required operation.
- Detection of changes in SW configurations and operation during power up and normal operations.
- Provide a mechanism to detect changes in data
- Provide a mechanism to support developmental unit test
- Provide a mechanism to support verification, validation, and qualification test

Types of Software Test Appliance

Techniques designed for hardware systems can be adapted for software systems

- Software Built-in Test (SW-BIT)
- Interface Logger (SW-INF)

Modes of SW-BIT

- Startup BIT
  - Evaluation of key functions and capabilities before transitioning to operational system status.
- Continuous BIT
  - Evaluation of selected capabilities during operational system status.

Modes of BIT (Cont.)

- Initiated BIT
  - Detailed BIT used to provide diagnostic information while temporarily transitioned to non-operational system status.
- Maintenance BIT
  - Exhaustive BIT designed to operate with a maintenance interface and provide “peek and poke” capabilities into system during both operational and non-operational system status.

Startup BIT

- Usually performed by the Boot Loader software.
- Evaluates memory locations using Destructive Stuck-on-1/Stuck-on-0 tests (memory is erased before download operations start).
- Downloads and verifies the operational code using sequence checking and check summing of the operational code.
- Activates all interfaces and verifies that they are operational by receiving/sending heartbeat messages.
- Activates operational code and verifies when it is running.

Continuous BIT (CBIT)

- Foreground Tests:
  - Inputs:
    - Checksum, parity checks, time tags, sequence numbers, and heartbeat checks of digital and discrete inputs.
    - Voltage, current, frequency checks of analog and power inputs.
  - Processors
  - Software
- Background Tests:
  - Inputs:
    - Perform loopback tests of digital, discrete, and analog input.
    - Non-destructive Stuck-on-1/Stuck-on-0 tests on interface buffers.
  - Memory:
    - Non-destructive Stuck-on-1/Stuck-on-0 tests of all memory locations.

Initiated BIT (IBIT)

- Detailed evaluations that may replace Startup BIT when adequate startup testing is too time-consuming.
- May be performed by operational code, however, IBIT is not performed during normal operation.
- Supports maintenance by:
  - Identifying *where* problems exist as well as problem types.
  - Providing an interface for maintenance software to access memory locations, etc.
  - Performing download evaluations.

Maintenance BIT

- Development Platform:
  – Provides access to selected memory locations, by setting of breakpoints, etc., used to evaluate the software and/or hardware.
  – Sets up emulated/simulated inputs and stimuli.
- Repair Operations:
  – Downloads new software via maintenance interfaces.
  – Identifies sources of problems for repair operations on LRU/SRUs.
  – Evaluates repair status.

Typical Test Procedures - Software

- Operational Evaluations Only – Does not include startup, development and V&V evaluations/tests.
- Examples of Operational Evaluations:
  - Data Analysis:
    - Perform sanity checks on input data.
    - Prevent run-time errors by insuring incorrect and out-of-bounds data are not used.
  - Stack Overflow – Provide software checks to insure against and report conditions where stacks overflow (especially necessary in "C", C++, and other languages).
  - Exception Handling – Provide exception handling capabilities in the code development.

SW-BIT: Detecting changes in SW configurations

- Startup SW-BIT checks:
  - Presence of data sources
  - Integrity of data sources (CRC)
  - Use of correct SW computational components (compare computed results against pre-computed expected results)
  - Expected behaviors from selected functional SW components
  - Correct model instantiation (software components, unique parameters, and specific data sources)

SW-BIT: Detecting changes during operation

- Continuous SW-BIT checks:
  - Integrity of data sources (CRC)
  - Use of calculation status (NaN & status flags)
  - Memory leaks
  - Buffer overruns
  - Program flow by choosing test cases that will to maximize code coverage

SW-BIT: During non-operation status

- Initiated SW-BIT supports regression testing:
  - SW tests that run during startup and under normal operation still return expected results
  - Test case stimulus chosen to maximize code coverage
- Maintenance SW-BIT
  - Test stubs
  - Upgrade verification/status

SW-BIT Summary

- Checks for expected:
  – Computational results
  – Control Flow
  – Required behaviors
  – Hardware and software system configurations
- Flags non-expected results
- Supports developmental test
- Logs test case stimulus for analysis

Interface Logging

- Include in operational requirements
- Test completely to avoid false failures
- Save all input information
- Save all output information
- Save needed state information
- Strategically capture the call trace
- Develop parsing tools to support analysis
- Identify interfaces where data can easily be gathered without intrusion.

Technique to enable logging

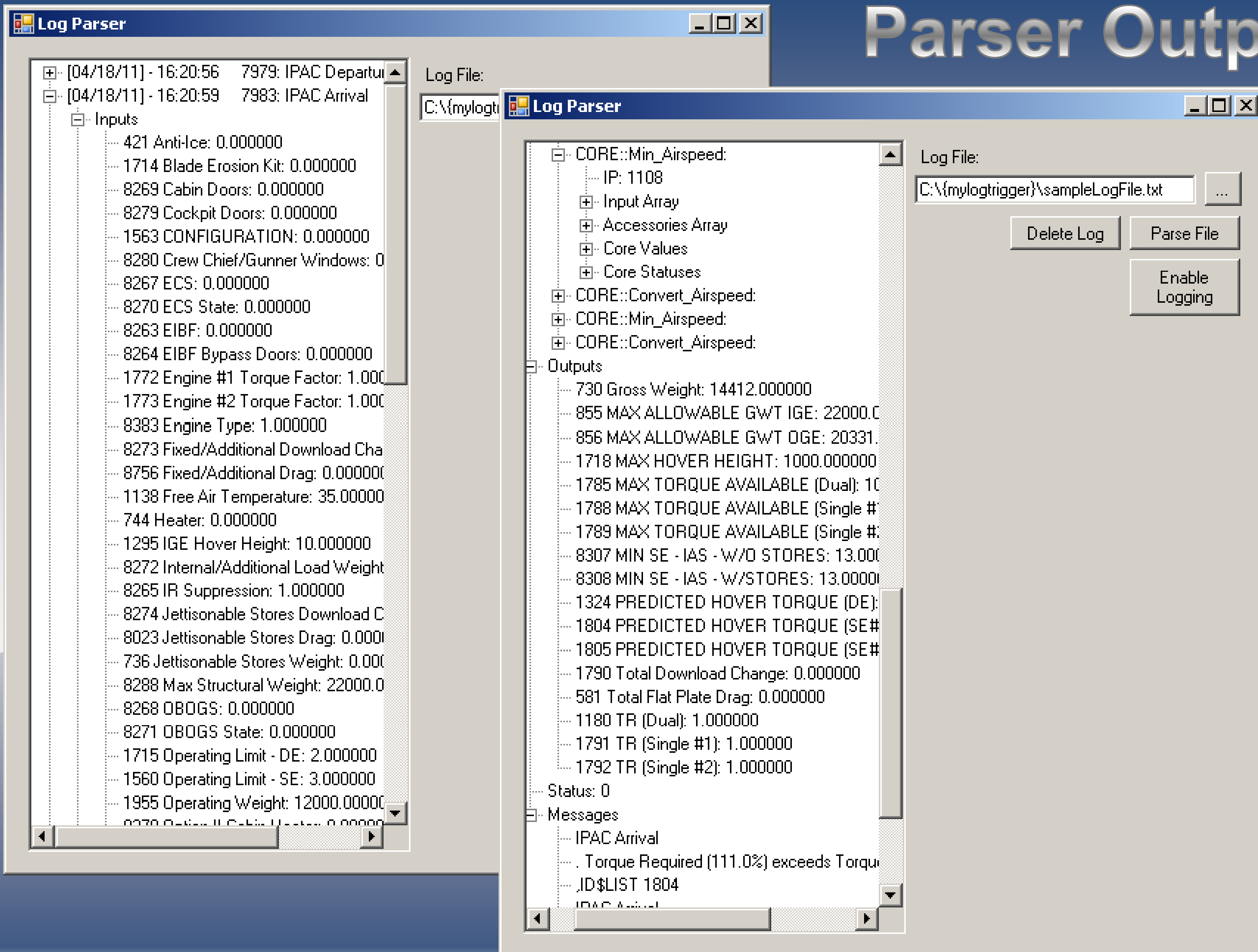
- Pick a simple technique that will not be accidently enabled

```
//
// See if Test Appliance is ready to be enabled
//
     //does the user want to enable logging?
     fopen_s(&logfile, "c:\\{5432testapp-papalog123}       \
                          \\eg45fhtymightbeagoodname.txt", "r");
     if (logfile != NULL)
     {
       logging = true;
       fclose(logfile);
     }
```

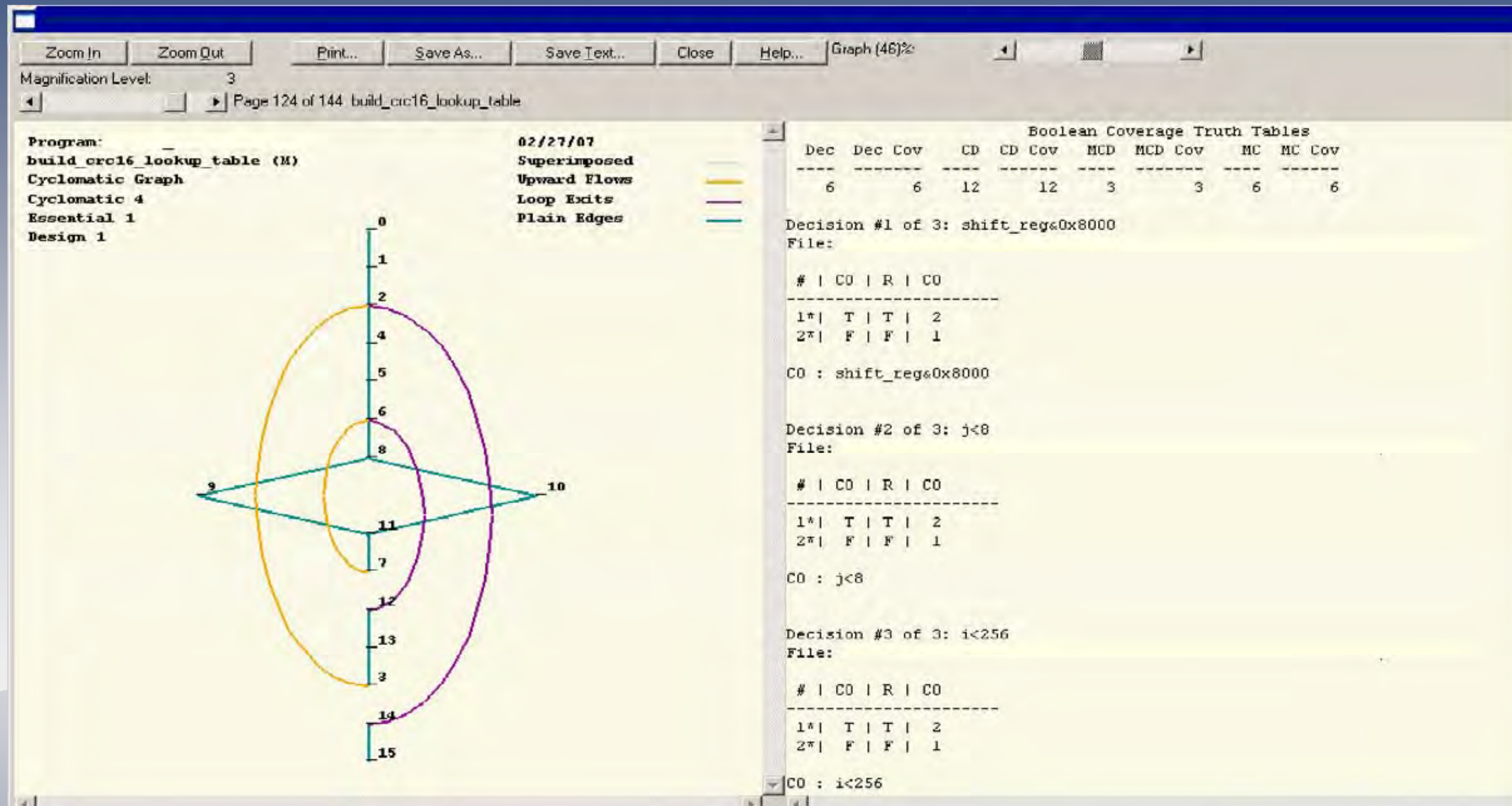
Logging Appliance

```
//
// Did we find a mode to calculate
//
  if(i < pModel->cModes)
    {
      if (logging == true )
     {
       // Write State info and input info.
       //  Flush the  file
       //  Close the File
     }

    ierr = pMyMode->prep_and_calc();   // Calculate the mode

     if (logging == true)
     {
       // Write the  output  info and state info.
       // flush the file
       // close the file
     }
   }
```

Parser Output



McCabe as a Test Appliance



Note: 3 decisions, 6 possible outcomes

Interface Logging Summary

- Provides call trace
- Parser can flags non-expected results
- Supports developmental test
- Logs test case stimulus for analysis
- Captured data can be fed back into application as a stimulus or regression
- Provides tangible test results